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Sequence Stratigraphic Study and Reservoir Prediction of Ekazy Field, Greater Ughelli Depobelt, Niger Delta, Nigeria

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Abstract

Biostratigraphic and wireline logs data were utilized and integrated to build a sequence stratigraphic framework model of 'Ekazy' field sediments. This work follows the Galloway's concept of genetic sequence stratigraphy. The study area comprises of a full sequence bounded top and base by maximum flooding surfaces with occurrence of transgressive system tract and highstand system tract respectively. The wireline log signatures indicate stacked prograding and retrograding lithofacies of deltaic channels with intermittent occurrences of upper and lower shoreface environmental deposits. The correlation with the reference well revealed that there are stratigraphic units occurring at deeper depths not penetrated in some other wells in the 'Ekazy' field. However, sand bodies within these sequences were found to be having reservoirs potential and as such were characterized into D1000 – D9500 and G1000 – G6000 horizons. The majority of the sandy horizons having reservoirs potential are occurring within the highstand system tract of the sequence. The highstand system tract setting which show good reservoir quality sand with possible occurrence of oil while transgressive system tracts with thick shale and few sand deposits suggest horizons with potential accumulation of gas. However, the observed sequence stratigraphic setting pointed to Oligocene epoch, spanning in age between 33.0/Ru*1Ma - 31.3/Ru*2Ma with characteristic shale markers of *Uvigerinella sparsicostata* and *Spiroplectammina wrightii* respectively. The identified shale marker, having regional extent, acts as a seal within the sequence stratigraphic framework.

Keywords: Sequence stratigraphy, Biostratigraphy, Correlation, Well logs, Greater Ughelli Depobelt.

Introduction

Documented studies carried out by geophysicist and geologists have shown that the Niger Delta Basin has maintained a thick sedimentary deposition with good geological features that favoured petroleum generation, expulsion and trapping from the onshore through the continental shelf and to the deep water settings. Reservoirs characterization requires integration of different types of datasets to define

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reservoir model. Sequence stratigraphic datasets often contributes to the definition of geometric, facies description and also ascertaining coherent reservoir continuity within a reservoir stratigraphic framework. To achieve this meaningful interpretation, biostratigraphic and sedimentological datasets has been utilized in this study. Adopting sequence stratigraphic approach to the development of oil fields has been a reliable technique in recent time in both academia and industry. All documented stratal stacking patterns reflect the interplay of two fundamental variables, namely accommodation (the space available for potential sediment accumulation) and sediment supply. Deposits defined by specific stratal stacking patterns form the basic constituents of the sequence stratigraphic unit, from sequence to systems tract and parasequence. Changes in stratal stacking patterns defined the position and timing of key sequence stratigraphic surfaces. Precisely, surfaces selected as sequence boundaries varies as a function of the surfaces which are best expressed within the context of the depositional setting and the preservation of facies relationships and stratal stacking patterns in that succession. Therefore high degree of variability in the expression of sequence stratigraphic units and bounding surfaces in the rock record means ideally that the methodology used to analyze their depositional setting should be flexible from one sequence stratigraphic approach to another. Construction of this framework ensures the success of the method in terms of its objectives to provide a process-based understanding of the stratigraphic architecture.

The stratigraphic framework, depositional environments of the 'Ekazy' field was delineated by well log correlation approach utilizing three wells within the studied project. The field which dated Early Oligocene - 'latest' Early Eocene age lies within the Greater Ughelli depobelt and is located on the eastern Niger Delta basin about 55km north onshore of the present day coastline and about 45.2km northwest of Port Harcourt. The depositional environment comprises of stacked prograding deltaic lithofacies channel sands stacked with shoreface deposits. Onshore sedimentary units of this depobelts of the eastern Niger Delta petroleum province are known to host large fields of oil and gas. Over time, integration of subsurface datasets has shown large sedimentary sequence of shales, siltstone and sandstone deposits are associated with other sedimentary structures within the environment. However, owing to the petroleum proliferation in the Niger Delta region, numerous documented, published and unpublished works have been done within the region both by industry professionals and academicians on stratigraphic studies and the reservoir predictions. The effective maximization and exploitation of hydrocarbon accumulation requires the full understanding of the reservoir beds and the pore space they contain, therefore, fundamental research of this nature on clastic sediments produces a wealth of published information on the maturation, distribution and continuity of the sandstones.

Wells located in the Greater Ughelli depobelt of the Niger Delta region, in which samples for this study has been provided accurately experienced lots of structural deformations due to the existence of fault structures. However, these faults have impacts on the stratigraphy within this sedimentary terrain, thereby causing facies changes. Work carried out by scholars and multinational companies within this depobelt utilizing sequence stratigraphic methods and empirical correlation techniques show that there are good structures although the quality of the reservoir sand encountered are poor. The problem of sandstone architecture with respect to their spatial distribution of lithofacies, stratal geometry and orientation can be solved with a total understanding of the sedimentological suites as may be exhibited by the wells in this environment. Integration of these datasets

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(Fig. 1) followed a stepwise order that led to the delineation of the geologic event as presented in the result and discussion section.

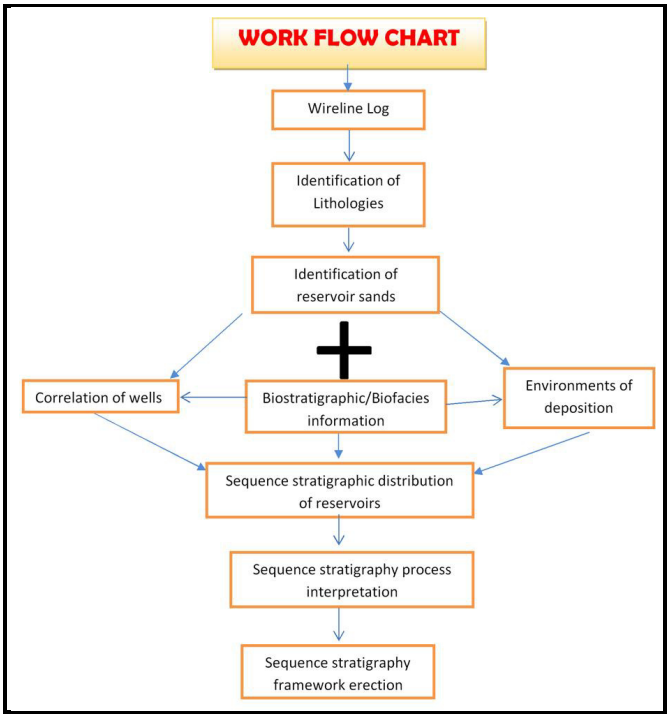

Figure 1. Study workflow chart.

Location of study

The Ekazy field covers an area of about 55km north onshore of the present day coastline and about 45.2km northwest of Port Harcourt (Fig. 2) with the wells being9 kilometers long and 7 kilometers (between well-001- well-002 and well-002 – well-003). The area is faulted and on the basis of the faulting, the field is divided into three fault blocks. However, the field lies to the eastern part of the Niger delta and is separated by a NW-SE trending bounding fault. The field is penetrated by three wells. To the west of the Ekazy area and slightly northward of the bounding fault lies the well-001 fault blocks with only one well penetrating the sediments. However, well-002 and well-003 were drilled in a separate fault block lying directly southward of the field.

Figure 2. Location of Ekazy field.

Geological setting and stratigraphy of Niger Delta

The Tertiary marginal Niger Delta basin development was a response to the sediment out building and flexural sag due loading caused by sediment offload or pass-by from the Cretaceous Anambra basin. The Niger delta sedimentary wedge consists of three distinct litho-units: the delta top Benin deposits, delta front Agbada deposit and the Pro-delta Akata deposits respectively. There also are streams of discrete depocenters or depobelts each defined by the limits of its arcuate proximal and distal facies pattern within the Agbada Formation and these are the Northern delta, Great Ughelli, Central delta, Coastal Swamp and Offshore depobelts. Each of these depobelts are estimated to occur 30 to 60 km wide (Fig. 3), with the oldest located furthest inland and the youngest depobelt occurring more distal into offshore (Reijers, 1996 and Reijers et al,. 1997).

During major progradational event, the delta top deposit advance over the Agbada deposits. Under the control of sediment loading, new depobelts bounding faults develop and sedimentation of Agbada deposits move towards this realm which previously was distal, thus creating a new, younger depocenter whilst the older depobelt is abandoned and covered by fluvial deposits of the Benin Formation. Major regional faults thus determine the location of each depobelt.

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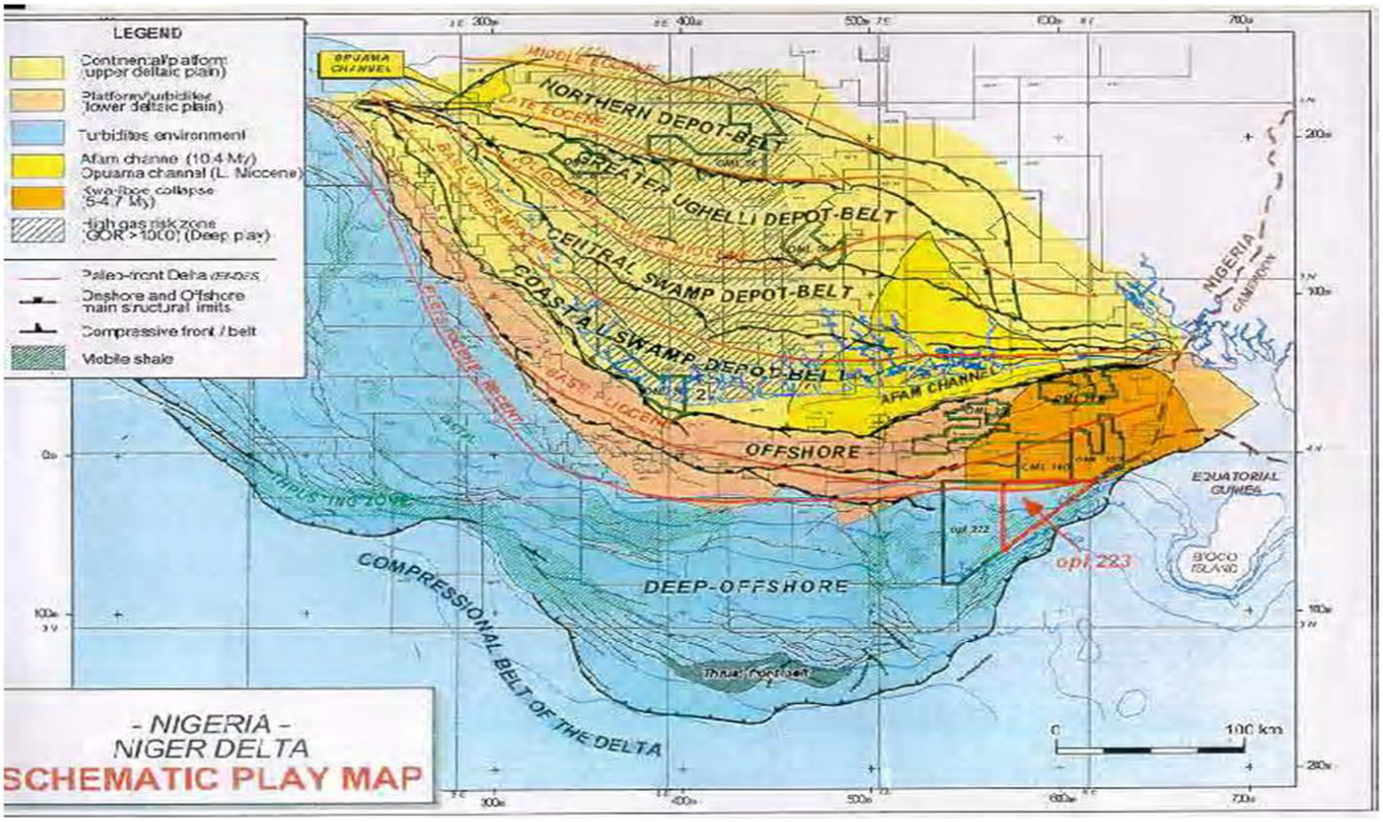

Figure 3. Paleogeography of Tertiary Niger delta (After Ejedawe, 1981).

The sedimentary wedge in the Niger delta has been laid down sequentially in five depobelts.

Sedimentation in the depobelts is dependent on the degree of the rate of deposition and the rate of sag with contemporaneous growth faults disturbing the delicate instability of the underlying shales (Evamy et al., 1978). The joint effect of continued sediment supply, contemporaneous faulting and relative base level fluctuations resulted in the continuous vertical cyclic stacking of fluvio-marine interlaminated sand, silt and clay usually followed by shoreface sands and coastal plain deposits, with gradual termination at the onset of the next transgressive phase (Weber, 1971). Active growth faults influenced the development of each cycle within the mentioned settings. The sedimentation mechanism in the depobelts was termed the "escalator regression" modeled by Knox and Omatsola (1989). On the down-thrown side of the major structural growth faults, the facies of the Agbada Formation accumulated in the depobelts when the ratio of sand is approximately equal to or less than one. Earlier studies in Greater Ughelli Depobelt of Niger delta was on deciphering control of faults in sandstone bearing reservoirs (Udoh et al., 2016). Udoh et al. (2016) inferred that reservoirs occurring in Greater Ughelli Depobelt are continuous despite occurrence of fault structures.

Lithostratigraphically, the Tertiary Niger Delta was deposited in three major sequences as observed by well sections drilled vertically within the Niger Delta environments. The lithostratigraphic units of this basin are strongly diachronous. Short and Stuable, (1967), Avbovbo, (1978), Petters, (1982) and many other workers have recorded major lithostratigraphic sequences, which are siliciclastic units, includes: the Benin Formation, Agbada Formation, and Akata Formation respectively (Table 1).

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Table 1. Lithofacies scheme for the Niger Delta (After Stacher, 1995).

FORMATION	LITHOLOGY		
	Sand (%)	Shale (%)	Ratio
Benin	90	10	9 : 1
Agbada	60	40	3 : 2
Akata	20	80	1 : 4

Materials and Methods

Well log data of three wells in the Ekazy field was provided with analyzed biostratigraphic/biofacies data of the reference well from the adjacent field, and was used as analogue well.

Well log motifs, header, deviation and datasets of these three wells were imported into a Petrel software after proper quality control was carried out on the data. A base map of the study area was generated after loading the various data types enumerated above. Posamentier et al., (1988) identified the first step in sequence stratigraphic interpretation as the determination of the general paleogeographic setting for the database in question and were adopted in this work. The second step was to interpret the depositional systems and facies using all available data. Different stacking patterns (coarsening upward, fining upward, blocky, symmetrical and serrated patterns) were observed and analysed in relationship with those below and above the individual parasequences to determine all the depositional systems. These ranges of patterns were compares well with those described by Rider (1986) and Cant (1984). Galloway (1989) proposed that a sequence be bound by maximum flooding surfaces and he named such a unit a genetic stratigraphic sequence. This methodology was based on Galloway's comprehensive subsurface work on the Tertiary strata of the Gulf of Mexico and built on the observations and interpretations of Frazier (1974). Frazier (1974) named a unit bounded by maximum flooding surfaces a depositional complex. The third step was to subdivide the stratigraphic succession through the identification of maximum flooding surfaces and sequence boundaries (Galloway, 1989; Loutit et al., 1988 and Van Wagoner et al., 1990). Gamma ray and resistivity log motifs were examined for the highest and lower peaks that could signify possible flooding surfaces, maximum flooding surfaces and sequence boundaries were also identified afterwards.

Results and interpretation

Stratigraphic development and biostratigraphic interpretation

Biostratigraphic data were used to interpret and erect the sequence stratigraphic structure of 'Ekazy' field. The datasets utilized in this work was derived from Ezema-10 well which served as the reference well. Inference drawn from the reference well showed that Ezema-10 well exhibited a fair to high foraminiferal taxa recovery which helped in the establishment of the delineated ages, zones, paleobathymetric and sequence stratigraphic framework (Tables 2, 3 and 4). Additional information derived from the log motifs, sedimentologic attributes and paleoenvironmental inputs from Ezema-10 well also helped in elucidating the sequence stratigraphic framework of the 'Ekazy' field sediments.

Only foraminiferal zones were provided and have been very useful in this interpretation. However, the analysis showed the penetration of microzones belonging to P16 – P17/18 of Blow, 1969, equivalent foraminiferal zone of F7200 – ?F7400/F7600 (SPDC) zones delineated and carried in this study. The information derived from the above stated foraminiferal zone was carried across the other wells in 'Ekazy' field and was observed to occur within the analyzing interval of 5755 – 7811ft. The results of biostratigraphic analysis showed that the reference well (Ezema-10) penetrated sediments of Early

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Table 2. Biostratigraphic/biofacies interpretation.

DEPTH	F.POPLN	F.DIVERS	P.POPLN	P.DIVERS	ENVIRON.	SURFACES	DATES AGE (Ma)	SYSTEMS TRACTS
8000	13	6	0	0	IN			
8030	14	10	0	0	IN			
8060	9	4	0	0	IN			
8090	4	4	0	0	IN			
8120	13	8	0	0	IN			
8150	5	5	0	0	IN			
8180	19	8	0	0	IN			
8210	3	3	0	0	SH.IN			
8270	11	5	0	0	IN			
8300	6	4	0	0	IN			
8330	5	12	0	0	IN			
8360	4	4	0	0	IN			
8390	24	6	0	0	IN			
8420	5	3	0	0	IN			
8450	14	9	0	0	IN			
8480	9	2	0	0	SH.IN			?TST
8510	8	5	0	0	IN			
8540	2	2	1	1	SH.IN			
8570	19	8	0	0	IN			
8600	9	4	0	0	IN			
8630	29	6	0	0	IN			
8660	10	5	0	0	IN			
8690	11	4	0	0	IN			
8720	10	6	0	0	IN			
8750	2	2	0	0	SH.IN	?SB	33.3Ma	
8810	20	5	0	0	IN			
8990	79	8	0	0	MN			
9170	94	14	2	2	MN-ON			
9260	40	13	1	1	MN			
9290	109	10	0	0	MN-ON			
9320	177	15	0	0	ON			HST
9350	2292	21	0	0	ON-UB	?MFS	34.0Ma	
9380	326	18	0	0	ON-UB			
9440	132	18	0	0	ON			
9500	148	10	0	0	MN			
9590	172	17	0	0	ON			
9680	183	23	0	0	ON			
9740	74	9	0	0	MN			
9800	125	15	0	0	MN-ON			TST
9830	33	9	0	0	IN-MN	SB	35.4Ma	
9890	45	10	0	0	MN			
9980	107	17	0	0	MN-ON			
10040	95	15	0	0	MN			
10100	62	14	0	0	MN			
10130	60	13	0	0	MN			
10190	77	18	2	4	MN			
10280	78	10	0	0	MN			
10370	212	17	0	0	ON			HST
10460	157	19	0	0	ON	MFS	35.9Ma	
10490	189	19	0	0	ON			
10550	109	7	0	0	MN-ON			
10610	175	12	0	0	ON			
10640	79	8	0	0	MN			
10730	57	13	1	1	MN			
10760	139	12	0	0	ON			
10790	70	7	0	0	MN			
10820	64	11	0	0	MN			
10850	49	9	0	0	MN			
10870	62	6	0	0	MN			
10940	67	9	0	0	MN			
10970	77	11	0	0	MN			
11100	74	11	0	0	MN			TST

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Table 3. Microfaunal zonation of Ezema-10 well (Interval 8,000 ft- 11,100 ft).

Top Depth (ft.)	Bottom Depth (ft.)	Foram. Zone	Age	Reliability Gradient	Remark
0	8000	No data	No data	-	-
8000	8150	?F7400	?Early Oligocene	4	Top occurrences *Hopkinsina bononiensis* & *Buliminella aff. subfusiformis*
8150	11,100	F7200	Early Oligocene – 'latest' Late Eocene	4	Top occurrences of *Brizalina ihuoensis* & *Virgulina - 15*

Oligocene - 'latest' Early Eocene epoch. The bathymetric/biofacies data used from Ezema-10 well (reference well) enhanced the overall comprehension of the respective environments of deposition delineated and in turn reflects on the relative sea level fluctuations. The employed abundance/diversified faunal abundance (benthic & planktic) taxa occurrences aided in the sequence stratigraphic build up interpretation as indicated in Table 2. The rise and fall in bathymetry changes (which principally showed the peak of the respective candidate surfaces – MFS & MRS) were observed by their retrogradational (finning upward) and progradational/aggradational parasequence sets pattern (shoaling-upward strata units). The rise in relative water level, which is accompanied by the transgressive systems tract (TST) terminated at the Maximum Flooding Surface (MFS) while the regressive phase (HST) culminated at the Sequence Boundary (SB) commonly typified by a type 1 sequence boundary which is often common in Niger Delta.

The stratigraphic build-up of the three (3) wells in this study field suggested the penetration of Agbada Formation observed from the paralic development of sand and shale (with silt intercalations) successions. The three wells in the Ekazy field showed occurrences of younger sediments as compared to the Ezema wells. However as shown in Table 5, Eazy-001 well encountered only one Maximum Flooding Surface; 31.3Ma MFS while Eazy-002 and Eazy-003 penetrated two Maximum Flooding Surfaces (31.3Ma and ?33.0Ma) each. All identified surfaces in these wells corresponded to the third order cycles chart of Haq et al., (1988) and are relevant for the sequence stratigraphic model building of the studied field sediments.

Table 4. Sequence stratigraphic summary of well-10 from biostratigraphic interpretation of Ezema field.

Depth Interval (ft)	Systems Tract/ Key Surfaces
3661 – 4443	LST (PGC)
4443	SB (?27.3Ma)
4443 – 5407	HST
5407	MFS (?28.1Ma)
5407 – 6399	TST
6399	SB (?29.3Ma)
6399 – 6876	HST
6876	MFS (?31.3Ma)
6876 – 7320	TST
7320	SB (32.4Ma)
7320 – 7801	HST
7801	MFS (?33.0Ma)
7801– 8734	TST
8734	SB (?33.3Ma)
8734 – 9434	HST
9434	MFS (?34.0Ma)
9434 – 9813	TST
9813	SB (35.4Ma)
9813 – 10, 465	HST
10, 465	MFS (35.9Ma)
10, 465 – 10, 969	TST

Shale Markers Delineation

The information derived from the foraminiferal zone of Ezema – 10 well when correlated across the wells in Ekazy field revealed the following marker shales: *Uvigerinella sparsicostata* Shale-As indicated in Fig. 4, the 31.3/Ru*2Ma MFS was encountered at 5944 – 6600ft in Ekazy field and at 6876ft in Ezema – 10 well. In correlation with the chronostratigraphy of the Eastern Niger Delta, this part of the studied section is

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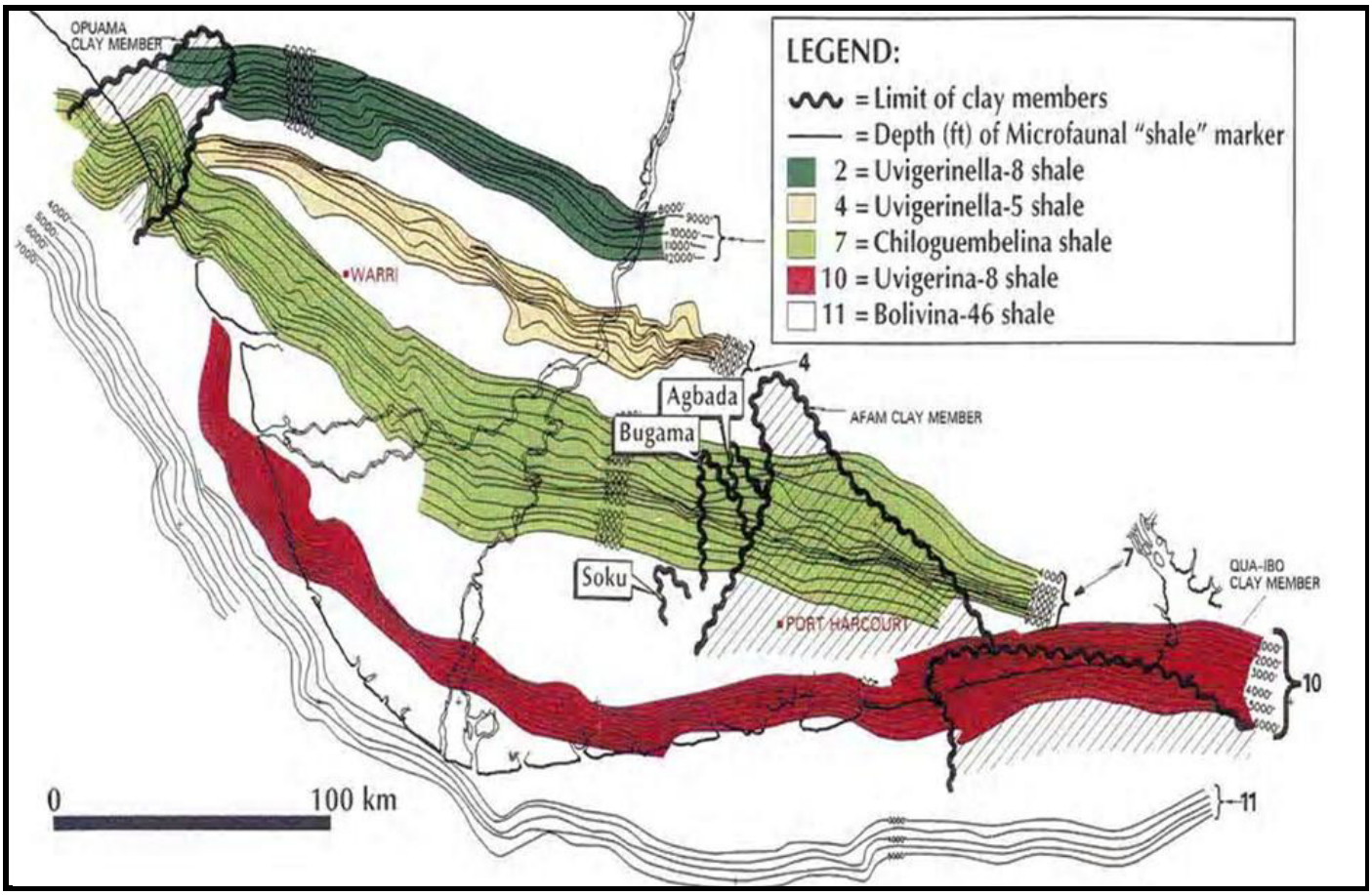

Figure 4. Regional third order shale markers with bands of sub-croping contours (After Reijers, 2011).

observed within the 'mid' Rupelian stage which occurred within Oligocene epoch.

Spiroplectammina wrightii Shale – This rock maker shale is dated 33.0/Ru*1Ma and was encountered at 7408 – 7505ft in Ekazy field and 7801ft in Ezema – 10 well. In correlation with the chronostratigraphy of the Eastern Niger Delta, this studied section is within the Rupelian stage and depicted the Early Oligocene age.

Depth Adjustment

In carrying out the sequence stratigraphic studies for the establishment of the Ekazy field's stratigraphic framework, the corresponding depths of the delineated MFS and SB were picked in MD and TVDSS as indicated in Table 5. There are minor differences in depth delineations as such adjustments in this respect

Table 5. Deliniated key surfaces with their corresponding depths in MD and SSTVD for Eazy-001, 002 and 003 wells.

Dated Surfaces	Eazy-001		Eazy- 002		Eazy-003	
	MD (ft)	SSTVD (ft)	MD (ft)	SSTVD (ft)	MD (ft)	SSTVD (ft)
MFS 35.9Ma	-	-	-	-	-	-
SB 35.4Ma	-	-	-	-	-	-
MFS 34.0Ma	-	-	-	-	-	-
SB ?33.3Ma	-	-	-	-	-	-
MFS ?33.0Ma	-	-	7505	7443	7408	7337
SB ?32.4Ma	6664	5977	6494	6433	6444	6375
MFS ?31.3Ma	6040	6600	6004	5944	6084	6016
SB ?29.3Ma	-	-	-	-	-	-
MFS 28.1Ma	-	-	-	-	-	-
SB 27.3Ma	-	-	-	-	-	-

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were done when compared with the depths values as recorded for the reference well (laboratory analysis results). This is probably eminent because of the petrel interface scale used and/or all the depths carried in this revise must honor all established horizons (Tops and Bases) within the correlation panel.

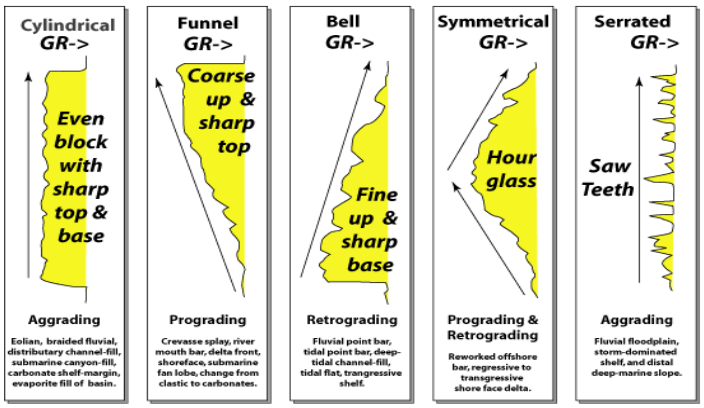

Figure 5. Standard log motifs for gamma ray response of lithologic unit (Modified from Emery and Myers, 1996).

Depositional Environments, Correlation and Sequence Stratigraphic Interpretation Pattern of Ekazy Field

Detailed well correlation was done with the established well tops in the whole Ekazy field. The encountered facies within the wells comprises of channels, barrier bars complexes, delta-marine fringes and restricted mudstones. The depositional environments delineated in this study consist of channels, shoreface sands (Lower shoreface and Upper shoreface), heterolithic and shales. These depositional settings were identified using wireline log motifs which puts it into smooth/cylindrical, blocky (erosional base), funnel and bell shapes respectively (Fig 5). Channel sands are cylindrical, blocky, serrated and often have fining upward units. However, channels settings in this study are characterized by their flat base features and therefore exhibited a range of readings from 20^0 – 70^0 API on the lithologic log. Upper shoreface sands are blocky with the reading range of 30^0 – 60^0 API on gamma ray log, while Lower shoreface sands have progradational upward sequence pattern with log value range of 45^0 – 90^0 API. The shales are either marine shales or coastal plain shales, their reading ranges from $>100^0$ – 150^0 API. Heterolithics (sediments that show almost equal proportion of sand/shale sediments) reading ranges from $<100^0$ API. These aforementioned environments commenced their depositions side by side, obeying Walther's law of facies correlation (Middleton, 1973).

All the candidate surfaces delineated in Ekazy field were dated accordingly using chronologically significant foraminiferal (planktic and benthic) bio-events in conjunction with correlation to the third order cycles chart of Haq et al., (1988). However, surfaces not dated did not carry any corresponding datum. The encountered sediments within Eazy-001 well were deposited in Delta plain – Open shelf setting (Fig. 6); within Non-marine (probably Coastal Deltaic) to Outer Neritic paleo-water depths. Owing to the fact that deeper horizons within the reference well (Ezema-10) were observed and analyzed, the Ekazy field which is at the shallower horizon could not account for those bathymetries.

Inference drawn from the candidate markers of the reference well which was carried across the wells in Ekazy field showed that the reservoirs of interest within the workable horizons in this project fall within D1000_Top – G6000_Top nomenclatures with interval depth of 5755 - 7811ft.

Table 6. Sequence stratigraphic summary of Eazy 001, 002 and 003 wells from biostratigraphic interpretation of Ekazy field.

Depth Interval (ft.)	Systems Tract /Key Surfaces
6399 – 6876	HST
6876	MFS (?31.3Ma)
6876 – 7320	TST
7320	SB (32.4Ma)
7320 – 7801	HST
7801	MFS (?33.0Ma)
7801– 8734	TST

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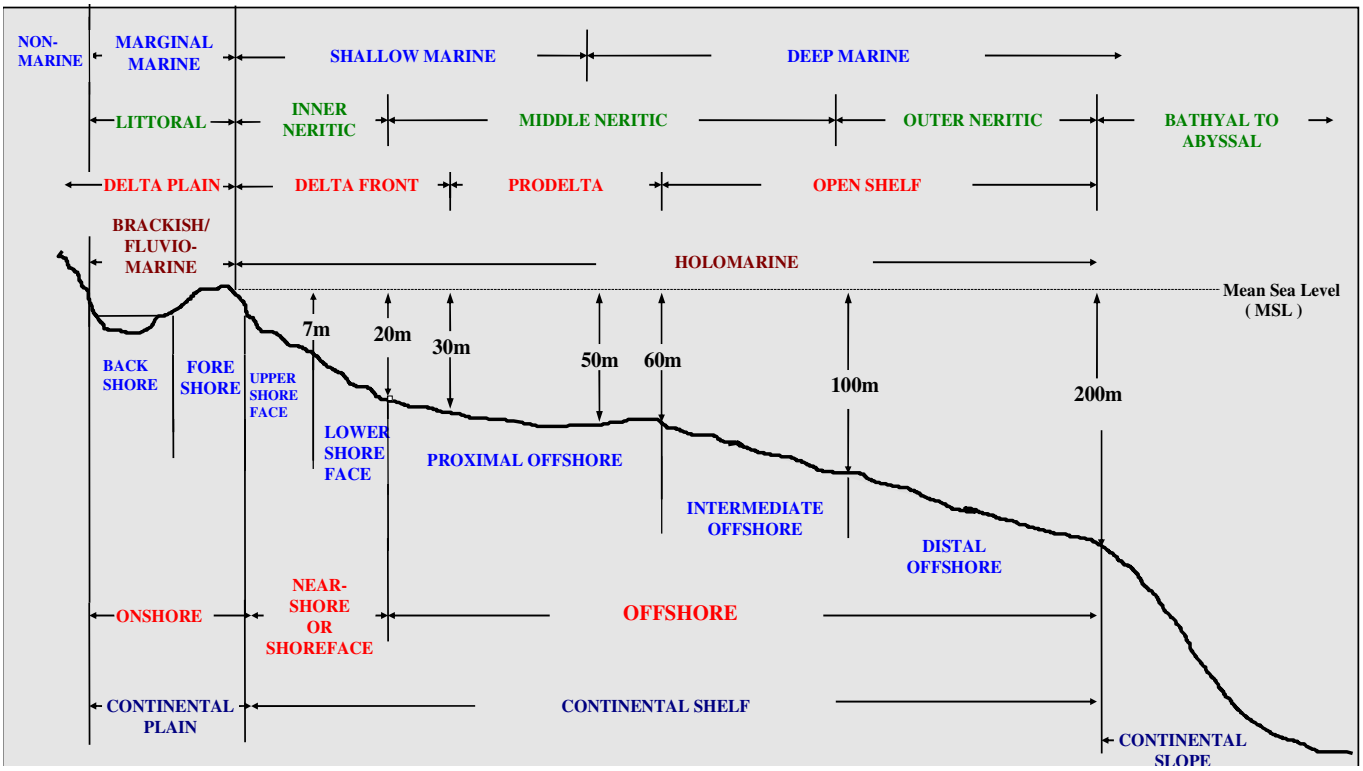

Figure 6. Various sub-environments from transitional setting through shallow to deep marine (Modified after Allen, 1965 & 1970).

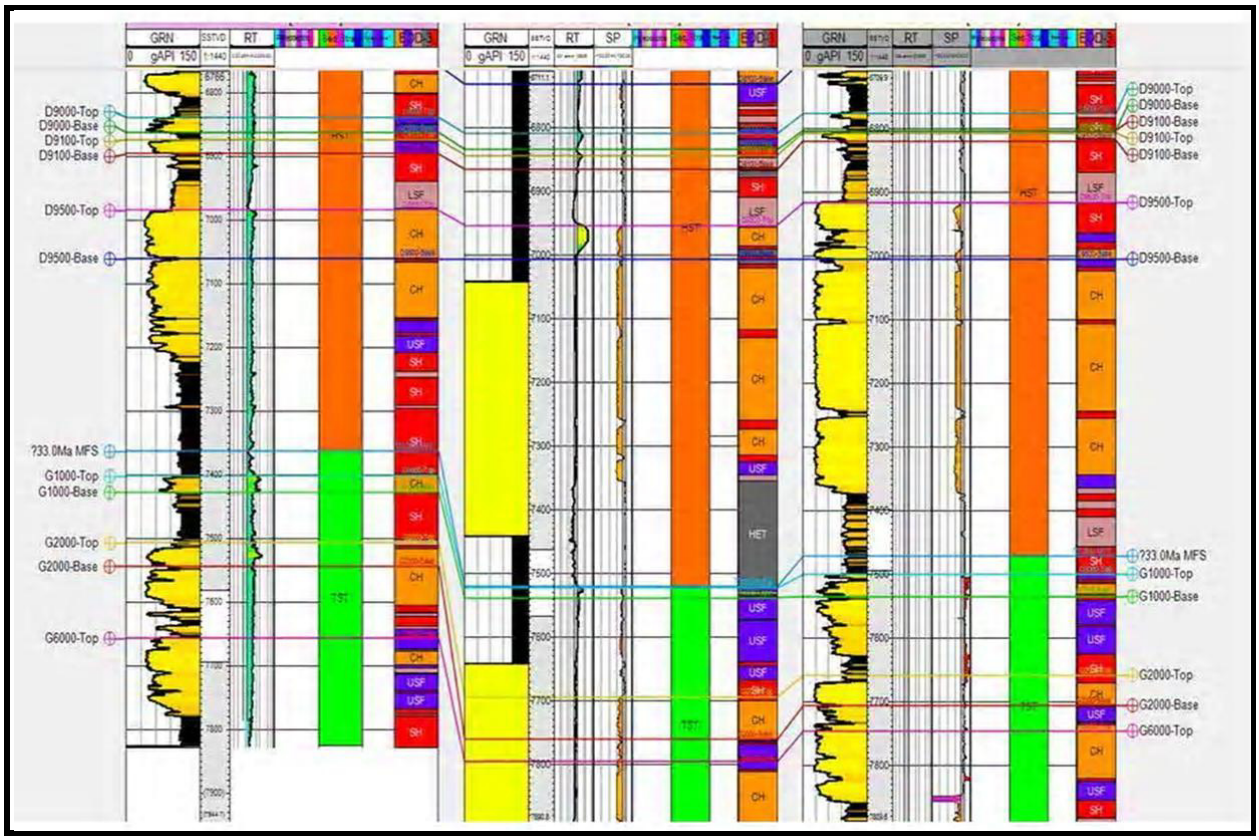

Figure 7. The 33.0/Ru*1Ma MFS encountered in Eazy-002 and 003 wells.

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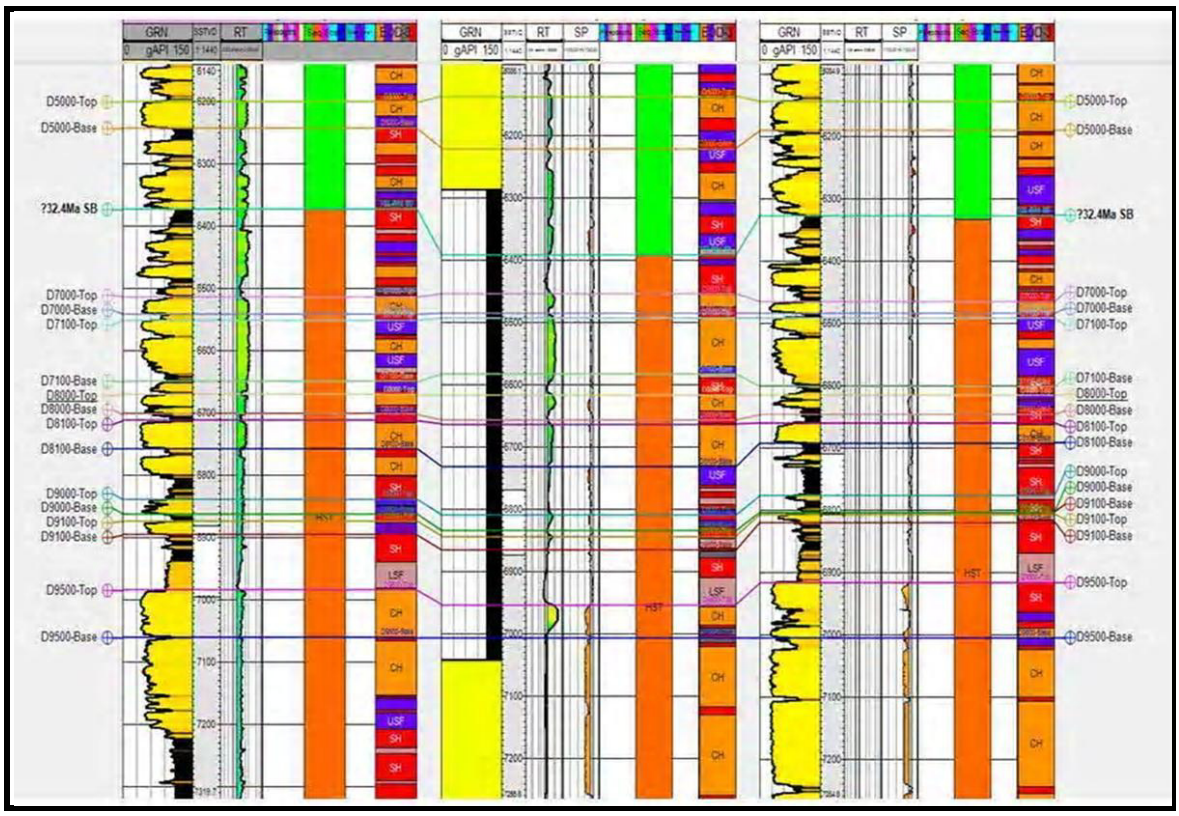

Figure 8. Well section sequence stratigraphy units above the 33.0/Ru*1Ma MFS.

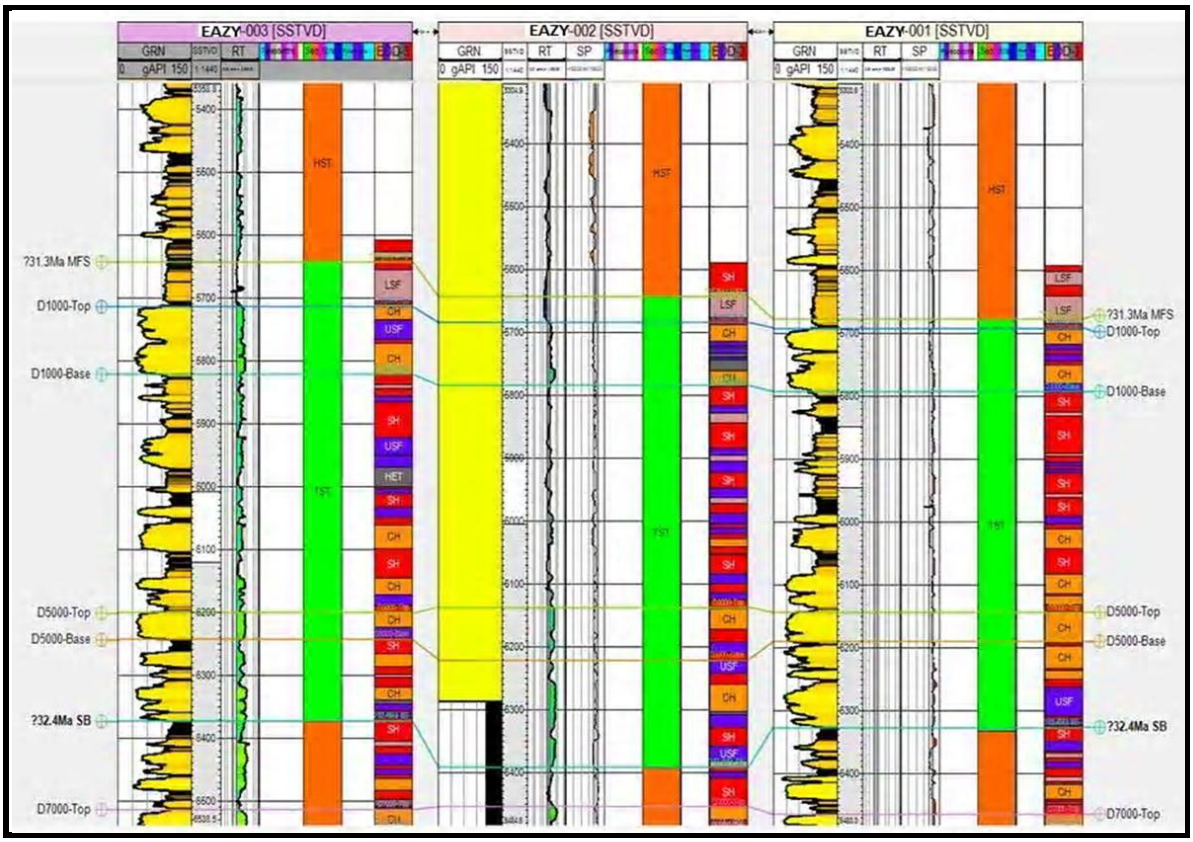

Figure 9. The 31.3/Ru*2Ma MFS encountered in Eazy-001, 002 and 003 wells.

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Sequence stratigraphic erection of Ekazy field showed that not all the wells attested the onset surface of the 33.0/Ru*1Ma MFS however, the ?34.0Ma MFS was not encountered within this section because of the shallowness in depth of the wells used (Table 6). It could be observed from the dataset that the 34.0Ma datum in the reference well (Ezema-10) occurred within the deeper setting. The sediments in Eazy-002 and Eazy-003 wells saw the initiated transgressive surface with coarsening and overall finning upward sequences which culminated at 7505ft and 7408ft and dated 33.0/Ru*1Ma MFS; Top *Spiroplectammina wrightii* datum. This surface was not encountered in Eazy-001 probably due to inherent fault occurrence. The paleobathymetric settings of these wells within this section were probably not certain as analysis within this section in the reference well was not given. This section was observed to fall within the considered horizon (D9500_Base – G1000_Top) of interest (Fig. 7).

Another depositional episode was experienced with subsequent regressive phase which witnessed the deposition of predominantly sand, minor shale and heterolithic occurrences within D9500_Base – D7000_Top horizons. Progressive shallowing of the sediments coupled with the relatively low base level changes resulted in the deposition of inter bedded channels, upper/lower shoreface sands, heteroliths and shale sediments which marked the end of this regressive phase and is dated ?32.4Ma SB (Fig. 8). All the three wells encountered this regressive surface. A renewed transgression was initiated above the highstand system tract but this horizon terminated at the argillaceous deposit deposited above the D5000_Top. The peak of this transgression (MFS) was delineated at 6084ft in this studies, with a relatively high gamma ray log value and low resistivity log values and is dated 31.3/Ru*2Ma MFS; Top *Uvigerinella sparsicostata*. Eazy-002 and 003 wells saw this horizon at the downthrown side relative to Eazy-001 well (Fig. 9). The paleobathymetric settings of these wells were not analyzed as the reference well (Ezema-10) only concentrated with the sediments deposited within the deeper horizons; as such absence of biofacies here impeded the accurate interpretation and delineation of the paleo-water depths within this unit.

Above the 31.3/Ru*2Ma MFS (Fig. 9), occurred the regressive phase associated with the highstand systems tract. This systems tract had fair occurrence of good sand deposition depicting a low level regime and terminated at the D1000_Top horizon. Their deposition was in a fluctuating environment in depths with the occurrences of predominantly channels, upper shoreface sands and heterolithic deposits. Sediments observed within this systems tract penetrated all the wells in this study. However, the peak of this regressive phase was not encountered within the analyzed section.

Chronostratigraphic study of Ekazy field

Interpretation deduced from the biostratigraphic data, shale markers and sequence stratigraphic framework of this section is dated as Early Oligocene - 'latest' Early Eocene age and it falls within the Rupelian Stage of the chronostratigraphic chart of Harland et al., (1990) and spans from *Spiroplectammina wrightii* (33.0/Ru*1Ma) to *Uvigerinella sparsicostata* (31.3/Ru*2Ma) marker shales. Ekazy field is found to occur within the eastern Niger Delta lithofacies units (see figure 10) as suggested by Doust and Omatsola, (1990).

Correlating the Ekazy field laterally to the western Niger Delta part (Fig. 4) confirms the benthic foraminiferal zones of *Hopkinsina bononiensis* and *Pseudo-hastigerina micra w*hich exist within the chronostratigraphic stage of Rupelian. This justifies the chronostratigraphic position and biozones of Ekazy field to lies within the Greater Ughelli

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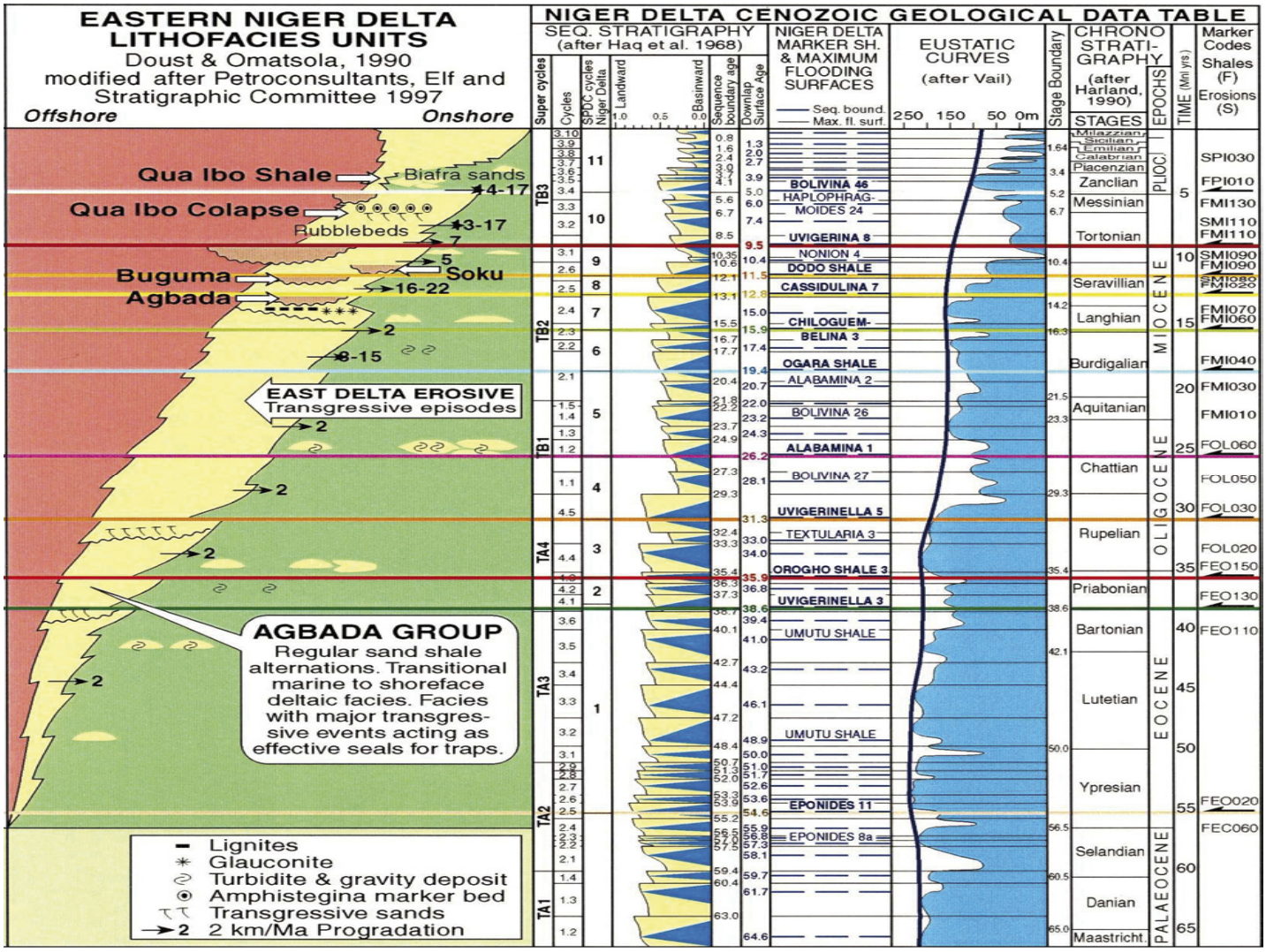

Figure 10. Eastern Niger Delta Lithofacies Unit Chart (After Doust and Omatsola, 1990).

depobelts as such Ekazy field is proposed to be a prolific zone for onshore hydrocarbon exploration.

Conclusion

Sequence stratigraphic interpretation utilising biostratigraphic and gamma ray log datasets indicated that the highstand systems tract has reservoir quality sand that may accumulate hydrocarbon while the transgressive systems tract contains, shale, a seal which may help accumulate hydrocarbon in place preventing further migration.

The D7000_Top – D1000_Top horizons in Ekazy field are dominated by channel deposits with minor upper/lower shoreface sands. The 31.3/Ru*2Ma MFS (*Uvigerinella sparsicostata*) was significantly encountered above the D1000_Top horizon and still acts as the seal. The D9500_Base – D5000_Top horizons in Ekazy field are dominated by channel deposits with minor upper/lower shoreface sands while the 32.4Ma sequence boundary was encountered below the D5000_Base horizon. The G600_Top – D9000_Top in Ekazy field showed predominance of channel deposits with minor shoreface sands. However, the 33.0/Ru*1Ma MFS (*Spiroplectammina wrightii*) was encountered above the G1000_Top horizon. In all, following the Galloway's principle, three cycles of deposition was

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encountered in the Ekazy field while one complete sequence cycle which comprises of highstand system tract and transgressive system tract with its top and base bounded by the maximum flooding surface.

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